THE PHLEGRÆAN FIELDS.

THE fired rocks and hills of volcanic origin stand in so striking a contrast to those of aqueous origin, that they have exercised a very powerful influence on the thoughts of man in all ages. Frequently associated with such formations are the phenomena which we are accustomed to refer to as volcanic—"burning mountains," boiling springs, gaseous exhalations, terrifying noises—all shrouded with a mystery which demands explanation. Even in a locality in which the volcanic fires have been extinguished or have long remained quiescent, the peculiar configuration of the ground often keeps alive the tradition of former outbursts of subterranean fire, and the tradition usually supplies the explanation of the configuration. The ancient Romans, long before the awful catastrophe of A.D. 79, seem to have been quite aware that Vesuvius had not always been in a condition to support the rich cultivation which covered its slopes in their day. It is only in rare cases that the inquirer is rewarded by finding that the history of a heap of burnt soil is preserved; more often he will hear vague stories of the direful effects of prehistoric struggles of Cyclops or other mythological monsters.

In a recent research[1] I have endeavoured, by examining the marks with which the Phlegræan Fields are scored, like a much over-written palimpsest, to collect materials for a history of the alterations which the surface of the country has undergone. Within the Phlegræan Fields, west of Naples, only two volcanic structures have been formed within the historical period. For trustworthy information respecting all structures but the Monte Nuovo and the lava stream from the Solfatara we are entirely dependent upon the facts collected by the geologist and the geographer. In my work I was chiefly guided by the desire of estimating how far the existing superficial configuration or morphography of a volcanic region is an indication of the past history of its development. With this end in view purely topographical features, selected according to certain principles, were studied, and from them a theory of their origin and relative age was constructed. The results obtained by the method admit of being tested by the results of geological research whenever the latter is possible.

The importance of a method which will yield information respecting the past history of a volcanic country from a mere superficial examination is very considerable. The volcanic regions of the sea-bottom and of the moon are alike inaccessible to the stratigraphical geologist. The only kind of information obtainable is that respecting the superficial configuration; and therefore it is of the greatest importance that the value of a method which will enable us to utilise this information, in reading the records of the past, should be carefully estimated by experiment within the sphere of the geological critic.

The Phlegræan Fields are well suited for the trial of such a method, because within a small area the face of the country records the results of long-continued volcanic activity and of denudation both by sea and rain. Within an area of not much more than fifty square miles are collected the assemblage of volcanic vents and crater walls, the presence of which distinguishes the Campi Flegrei from the adjoining level plains of fertile volcanic soil of the Campagna Felice, stretching right away inland to the limestone slopes of the Apennines.

By far the most important topographical features within this region are composed of loose ashes or of compacted tufa. Lava-streams or heaps of lava characteristic of so many other volcanic regions cover but a small part of the surface of the country at the present day; in the future, no doubt, their harder, more resistent qualities will cause them to stand more prominent when the forces of denudation have removed the superincumbent layers of more readily erosible tufa.

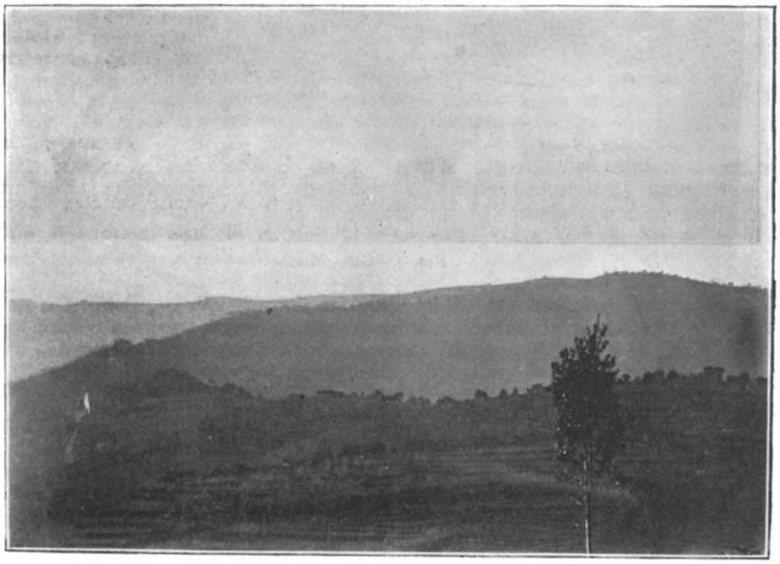

FIG. 1.—Crater of Astroni from the North-East. In the distance is part of the crater wall of Archiagnano culminating in the Torre Nocera.

Many of the hill forms are readily reducible to the simple type of a volcanic crater wall surrounding a crater, such as is naturally formed by fragmentary materials ejected from a vent and allowed to fall uniformly around that vent. In the Phlegræan Fields there are five almost perfect examples of such volcanic ring walls. Of these, Monte Nuovo is still to be seen in much the same condition as it was immediately after its eruption in September 1538. The Fossa Lupara, Solfatara, Astroni and Cigliano are hardly less perfect examples of typical volcanic craters. The topographical aspect of all is identical. In each a crater is entirely surrounded by an almost circular wall, which has a steep and sometimes precipitous crater-slope on the inside, but a more gradually inclined cone-slope on the outside.

In addition to these hills, which are volcanic cones of the first rank of symmetry and preservation, there are others which are not less certainly volcanic cones produced in the same way, but which have had their symmetry marred by the removal of their flanks, either by marine erosion or by destructive eruption from an adjacent volcanic vent. The walls of the craters of Capo Miseno, Porto Miseno, Bacoli, Campiglione and Nisida, have all been more or less removed on the side turned towards the sea, and, with the exception of the Campiglione crater wall, are still being eroded away at the present time. The craters of Porto Miseno and Nisida are submerged, and being in communication with the open sea by breaches in their walls, afford good harbours for small vessels. The floors of the other craters are above sea-level. On the other hand, the

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[1] "The Phlegræan Fields." By R. T. Günther. (*Geographical Journal*, 1897, vol. x. pp. 412–435, and 477–499, with 8 maps and 15 figures.)

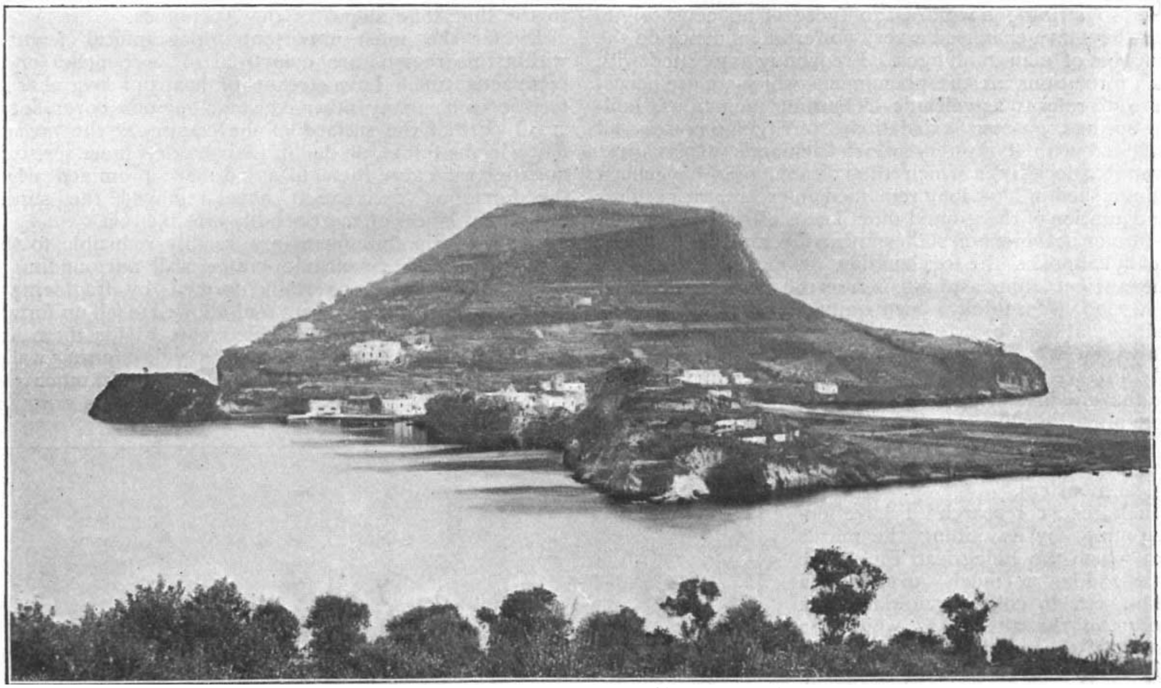
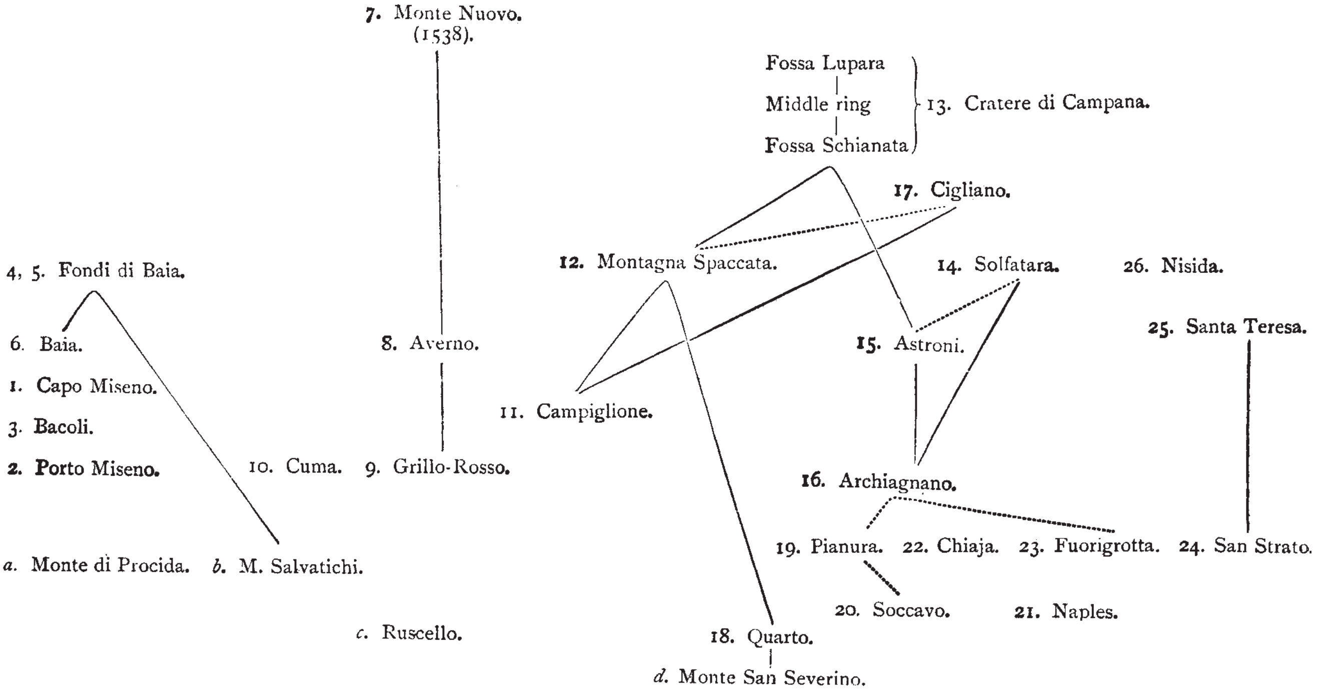


FIG. 2.—Capo Miseno from the Northern side of Porto Miseno.

crater walls of the Fondi di Baia, Lago d'Averno, and the two outer crater rings of the Cratere di Campana, have been partially obliterated by outbursts from other volcanic vents on or near their periphery.

TABLE SHOWING SUPPOSED CHRONOLOGICAL ORDER OF FORMATION OF VOLCANOES OF PHLEGRÆAN FIELDS.



In all these cases of partially destroyed crater walls, their shape on the whole agrees very well with that of the five perfect crater walls enumerated above, and with the generalised type of a volcanic cone composed of fragmentary materials. In fact, there seems little reason to doubt their origin as segments of volcanic crater walls.

Passing now from the hills which bear a more perfect resemblance to a typical crater wall to those in which the resemblance is less perfect, I have been led to adopt the following criteria as indications: firstly, of whether a hill can be regarded as a segment of a volcanic crater wall or not; and, secondly, of the position of the volcanic crater.

(1) If a hill is convex towards one side and concave towards the other, it is assumed that the crater which it formerly surrounded was situated on the concave side; and the radius of the crater at any level is indicated by the radius of the arc formed by the horizontal projection of the horizontal curve of the crater slope at the same level.

(2) A further indication of position is afforded by the fact that in almost every case the natural crater slope is much steeper than the corresponding cone slope.

(3) If arc-shaped hills be so situated that a curve approaching a circle can be drawn so as to pass along all their ridges, it is an indication that the hills are parts of one and the same crater wall.

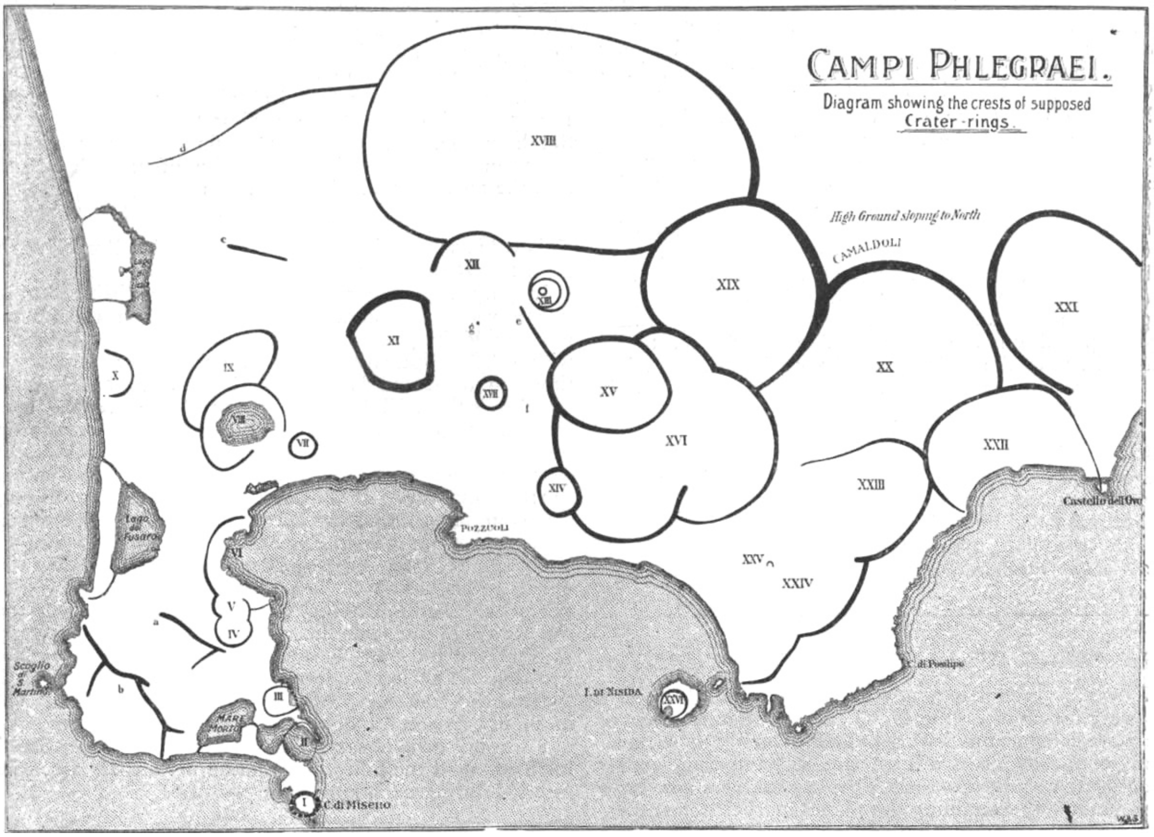
(4) In the Phlegræan Fields there is nothing more common than to find volcanic cones denuded on the side facing the sea. It is, therefore, probable that the last vestiges of a volcanic crater ring will be on the land side.

Examined with especial regard to these points, the hills of Baia, Monte Grillo and Monte Rosso, Cuma, Montagna Spaccata, and many others admit of interpretation as segments of volcanic crater walls. Lastly, there are some hills which may possibly be remnants of volcanic cones; but if they are, they are so worn and denuded that I have not been able to assign any position on satisfactory evidence to the vent from which they have been erupted.

The hills of the Phlegræan Fields which are considered to have once formed part of the walls of volcanic craters whose position is sufficiently well-indicated by the criteria enumerated above, are shown in the accompanying map. The map was constructed by drawing lines along the highest ridges of the hills enclosing undoubted volcanic craters, and then along those of less certain origin. The lines were then thickened according to a definite scale in which the breadth of line was made proportional to the height of the hill above sea-level. The highest hills in the north-east are over 1500 feet above sea-level, and are represented by the broadest lines.

One of the most striking features brought out in this map is that several of the crater-ring walls end abruptly in the circumference of others. Where this is the case it is assumed that the crater wall ending in the other is the product of a more ancient eruption. If this assumption prove to be correct, we have a very easily observable indication of the relative ages of the intersecting hills. Confirmatory evidence is often supplied by the physiographical characters of the hill slopes themselves. The slopes of the older crater walls seem to be, as a rule, less steep, and to exhibit the weather-worn scars of erosion and denudation to greater perfection than the steeper gradients of the younger crater slopes.

In the table given on p. 584 are set forth the volcanic structures so as to indicate their chronological relationships, so far as I have been able to make them out. The only crater of known age is Monte Nuovo: the most



EXPLANATION OF MAP.

I.	Capo Miseno	X.	Cuma	XVIII.	Quarto	XXVI.	Nisida
II.	Porto Miseno	XI.	Campiglione	XIX.	Pianura	*a.*	Monte Salvatichi
III.	Bacoli	XII.	Montagna Spaccata	XX.	Soccavo	*b.*	Monte di Procida
IV., V.	Fondi di Baia	XIII.	3 Cratere di Campana	XXI.	Naples	*c.*	Monte Ruscello
VI.	Baia	XIV.	Solfatara	XXII.	Chiaja	*d.*	Monte San Severino
VII.	Monte Nuovo	XV.	Astroni	XXIII.	Fuorigrotta	*e.*	Pacifico ridge
VIII.	Lago d'Averno	XVI.	Archiagnano	XXIV.	San Strato	*f.*	Astroni-Cigliano ridge
IX.	Monte Grillo, Monte Rosso	XVII.	Cigliano	XXV.	Santa Teresa	*g.*	Crisci mound

salient features of its eruption were recorded by an eye-witness in the sixteenth century. The others probably date from prehistoric times; otherwise, such a marvel as an extensive eruption could not have escaped mention by some Greek or Roman author. In the table, the younger volcanic structures are arranged above those which are considered to be older, and lines connect those between which it is thought that some evidence of relative age can be detected.

In my recent paper I have shown that almost all the hills of the Phlegræan Fields are either the entire walls of volcanic craters or of portions of walls of volcanic craters which have been to a greater or less extent washed away by the action of rain or the sea, or have been partially destroyed or buried by more recent volcanic eruptions. Secondly, these volcanic craters are distributed over a crescentic area round the Bay of Pozzuoli; the more recent ones are situated closer to the shore of the bay than the older ones, indicating a gradual march of volcanic vents along lines radiating towards the centre of that bay. In other words, the general effect of volcanic activity has been the accumulation of new land around the bay of Pozzuoli. Inasmuch as water seems to be a necessity for a volcanic eruption, this progression of the volcanoes seawards may stand in some relation to the channels by which water has obtained access to the fires below.

Thirdly, wherever crater rings of a larger and smaller diameter overlap, we never find a larger ring superimposed on a smaller one. The smaller ring is always superimposed on the larger. The conclusion to be drawn is, that the volcanic activity of the region has been decreasing in intensity. The same proposition is proved for a single locality by the Campana series of craters.

As it is impossible to make all the above-mentioned points clear without a suitable map, I would draw the attention of the interested reader to the surveys of the region published by the Istituto Geografico Militare, and to the contoured map published in the *Geographical Journal* for October 1897. R. T. GÜNTHER.

THE PRESENT APPEARANCE OF JUPITER.

IT may be interesting, now that the planet Jupiter is very favourably situated, to call attention to a few of the more conspicuous features which diversify its surface. Many of these objects will be sure to have come under the repeated observation of all those observers who have been habitually examining the planet in their telescopes.

It is fortunate that at the present time there are a large number of conspicuous markings on the planet. These are situated in different latitudes, and will allow some excellent redeterminations to be made of the velocities of the various longitudinal currents.

There are a great many dark and bright spots visible near the equator, on the north side of the southern equatorial belt. Some of these at the date of writing (April 18) are placed in the following longitudes, which are computed on the basis of System I. (daily rate 877°·90 = 9h. 50m. 30s.) in Mr. Crommelin's ephemerides in *Monthly Notices* for January 1898.

	Bright spots.	Dark spots.
	°	°
Long.	80	71
,,	146	94
,,	209	116
,,	238	127
,,	270	155
,,	349	216
		279
		319
		355

These markings are moving at approximately the same rate as the zero meridian System I., but I find that in several cases there is a disposition of the spots to decrease in longitude; hence I believe that their rotation periods will prove to be slightly less than 9h. 50m. 30s. The bright spots exhibit great variations in their appearance, and some irregularities of motion. A spot which is conspicuously brilliant on one night may, a few evenings later, have declined so much that it can scarcely be discerned.

The great red spot is still visible, and its present longitude is about 24°, so that it follows the zero meridian of System II. in the ephemerides by about forty minutes. The spot has the aspect of a faint dusky ellipse with a light interior, and it is connected on its south side with a grey belt. The recent motion of the spot corresponds with a period of 9h. 55m. 41·5s., and it may be expected to drop further behind its computed place unless an acceleration of motion should set in. Comparing an observation of the spot which I obtained on April 17, 1898, 12h. 5m., with one of the earliest by Mr. Dennett, of Southampton, on July 27, 1878, I find that 17,414 rotations were performed in the interim of 7203 days, and that the mean period of rotation was

9h. 55m. 39·4s.

This value is identical with that found by Prof. Hough from 14,505 rotations between 1879-96.

In July 1898 the spot will have been visible during twenty years, and under careful observation at each opposition of the planet. Whether this object is identical with other elliptical or reddish spots seen at various times in the same latitude by Dawes (1857), Huggins (1858-59), Gledhill (1869-70), Lord Rosse (1873), Copeland (1873), Russell (1876), and others, must remain an open question. It appears highly probable that the spot was the same as that observed by Russell in the summer of 1876, but there is an absence of connecting observations in 1877. And the identity of two or more markings cannot be absolutely proved by their longitudes when a fairly long interval has intervened between the observations, because the proper motions of the object are variable, and introduce great differences of longitude not always in the same direction. The retarded westerly drift of the red spot has caused it to lose more than 900 degrees of longitude relatively to its place in 1878, so that the spot has really been displaced to the extent of about two and a half circumferences of the planet.

From my own observations of the spot since 1880, I have obtained the following rotation periods for a certain interval during each apparition:—

Limiting observations.	Rotations.	Period. h.	m.	s.
1880 Sept. 27-1881 March 17	413	9	55	35·6
1881 July 8-1882 March 30	640	9	55	38·2
1882 July 29-1883 May 4	674	9	55	39·1
1883 Aug. 23-1884 June 12	710	9	55	39·1
1884 Sept. 21-1885 July 8	700	9	55	39·2
1885 Oct. 24-1886 July 24	659	9	55	41·1
1886 Nov. 23-1887 Aug. 2	609	9	55	40·5
1888 Feb. 12-1888 Aug. 22	462	9	55	40·2
1889 May 28-1889 Nov. 26	439	9	55	40·0
1890 May 22-1890 Nov. 25	451	9	55	40·2
1891 Aug. 7-1892 Feb. 2	432	9	55	42·2
1892 Aug. 15-1893 March 8	495	9	55	42·3
1893 Aug. 9-1894 March 24	548	9	55	41·2
1894 Nov. 25-1895 May 10	401	9	55	41·2
1895 Aug. 24-1896 Feb. 22	439	9	55	41·3
1896 Sept. 27-1897 April 25	514	9	55	40·8

The red spot has been falling behind the zero meridian during the last six or seven years, but at a very slow rate, the mean annual retardation being only about six minutes.

There are a number of dark, elongated spots or short belts placed in various regions of the planet. They are